Atty. Docket No. OPP031051US
Serial No: 10/722,295

Remarks

Applicant and his representatives thank Examiner Chen for the helpful and courteous discussion held with the undersigned representative on May 9, 2006. Claim 1 has been amended as discussed to include an organic antireflection layer and a trench having sloped sidewalls to further distinguish the claims from the cited reference (to Moore et al.). No new matter is introduced by the present Amendment. The new matter issues are also addressed below, as discussed. The following remarks shall further summarize and expand upon topics discussed.

The present invention relates to a method of forming a trench in a semiconductor device, including the steps of (a) forming a polish stop layer on a semiconductor substrate, (b) forming an organic anti-reflection coating on the polish stop layer, (c) selectively etching the anti-reflection coating to form an anti-reflection coating pattern, (d) etching the polish stop layer and etching the semiconductor substrate to a predetermined depth to form a trench such that ends of the polish stop layer adjacent to the trench are rounded and the trench has sloped sidewalls, and (e) forming an insulation layer that fills the trench.

The Objection to the Amendment under 35 U.S.C. § 132(a) and the Rejection of Claims 2-4, 8-10 and 15-17 under 35 U.S.C. § 112, first paragraph

The objection to the Amendment filed September 16, 2005 under 35 U.S.C. § 132(a) and the rejection of claims 2-4, 8-10 and 15-17 under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement is respectfully traversed.

The Amendment filed September 16, 2005 does not introduce new matter. Rather, the Amendment filed September 16, 2005 is supported by the original disclosure. As discussed on May 9, 2006, the etchants recited in claims 2-4, 8-10 and 15-17 are all well-known in the art (although the structure being etched and the result of etching, as claimed, are not). Further, as discussed on May 9, the disclosures in the specification of:

- "Dry etching" the silicon nitride (polish stop) film 13, the pad oxidation layer 12 and the semiconductor substrate 11 form a trench 100 (see paragraph [0030], p. 7 of the application as originally filed) and
- Forming "a sidewall polymer" during dry etching (see paragraph [0033], p. 8 of the application as originally filed)

inherently encompasses (and thus discloses) mixtures of the etchants recited in claims 2-4, 8-10 and 15-17. Thus, one skilled in the art of semiconductor processing and/or manufacturing understands that the amendments to claims 2-4, 8-10, and 15-17 filed September 16, 2005 are supported by the specification as originally filed.

For example, the present specification discloses dry etching the silicon nitride (polish stop) film 13, the pad oxidation layer 12 and the semiconductor substrate 11 form a trench 100 (p. 7, ll. 14-17), and forming a sidewall polymer in the initial stages of etching the silicon nitride layer 13 (and removing the same) such that the ends of the ARC 14 are etched. One skilled in the art understands that forming a sidewall polymer also occurs when dry etching SiO_2 (e.g., a material suitable for pad oxidation layer 12) and Si (the best-known and most widely used semiconductor substrate) with a fluorocarbon plasma (see, e.g., Wolf, "Silicon Processing for the VLSI Era," vol. 1, pp. 678-683, particularly p. 678, first paragraph, p. 680, Fig. 14-19(b) and paragraph #2, and p. 683, Fig. 14-23 and the first full paragraph; attached to the Amendment filed March 20, 2006).

Notably, Wolf teaches the well-known formation of sidewall polymer in a process that etches a trench into silicon under a layer of SiO_2 (a well-known structure resulting from the oxidation of silicon) using a mixture of CHF_3 and CF_4 (both of which are recited in claims 2-4, 8-10 and 15-17), or a mixture of a fluorocarbon and O_2 (the latter of which is recited in claims 2-4, 8-10 and 15-17; see Wolf, p. 683, the first paragraph, ll. 11-16, and Fig. 14-23). Therefore, one skilled in the art(s) of semiconductor devices and semiconductor manufacturing would readily understand that the present specification supports dry etching a silicon nitride (polish stop) layer and a semiconductor substrate using a mixture of the CHF_3, CF_4 and O_2 etchants recited in claims 2-4, 8-10 and 15-17. Thus, the present application as originally filed inherently

discloses etching a polish stop layer and a semiconductor substrate using a mixture of the CHF_3, CF_4 and O_2 etchants recited in claims 2-4, 8-10 and 15-17.

As discussed on May 9, Applicant's undersigned representative understands that O_2 itself does not dry etch silicon nitride, SiO_2 or Si (see also, e.g., Wolf, p. 672, Table 14-2, submitted with the Amendment filed March 20, 2006). As a result, one skilled in the art would understand that, to the extent O_2 is used in dry etching, the silicon nitride (polish stop) film 13, the pad oxidation layer 12 and the semiconductor substrate 11 must be etched with a mixture of O_2 and another etchant (e.g., CF_4; also see Wolf, p. 673, first paragraph of section 14.4, and Table 14-2 on p. 672). As a result, one skilled in the art(s) of semiconductor devices and semiconductor manufacturing would further understand that the present specification supports dry etching a silicon nitride (polish stop) layer, a pad oxidation layer 12 and a semiconductor substrate using a mixture of the etchants including O_2 and CF_4, as recited in claims 2-4, 8-10 and 15-17. Thus, the present application as originally filed inherently discloses etching a polish stop layer, a pad oxidation layer and a semiconductor substrate using a mixture of the O_2 and CF_4 etchants recited in claims 2-4, 8-10 and 15-17.

In addition, the present specification discloses that the antireflection coating ARC 14 may be a conventional ARC made of an organic material (p. 7, l. 7-8), and that dry etching to form the trench 100 can be controlled such that a small amount of exposed ends of the ARC layer 14 is removed (p. 7, l. 20-p. 8, l. 1). As is known in the art, dry etching an organic solid (such as the embodiment of the ARC 14 disclosed by the present specification and discussed in this paragraph) can be done with O_2 alone or in combination with CF_4 (see Wolf, p. 672, Table 14-2). As a result, one skilled in the art(s) of semiconductor devices and semiconductor manufacturing would understand that the present specification supports dry etching an organic ARC using one or more of the etchants recited in claims 2-4, 8-10 and 15-17. Thus, the present application as originally filed inherently discloses etching an organic antireflection coating using a mixture of the O_2 and CF_4 etchants recited in claims 2-4, 8-10 and 15-17.

Even further, one skilled in the art understands that *molecular* gases are used in dry etching (see, e.g., Wolf, pp. 668-9, particularly p. 669, l. 7, attached hereto; emphasis in

original). One of the gases recited in claims 2-4, 8-10 and 15-17, Ar (argon), is not a molecular gas. Accordingly, one skilled in the art understands that Ar is not used alone in dry etching (see also, e.g., Wolf, p. 679, the second full paragraph, which teaches the well-known use of Ar ions to ***assist*** dry etching processes). One skilled in the art therefore understands that dry etching uses a molecular gas such as CHF_3, CF_4, O_2, or HeO_2, and as a result, the disclosure of Ar as a gas for use in dry etching must refer to its use in combination with one (and possibly more, as discussed above) of the molecular gases recited in claims 2-4, 8-10 and 15-17. Thus, the present application as originally filed inherently discloses etching a polish stop layer, a pad oxidation layer and/or a semiconductor substrate using a mixture of Ar and at least one of the CHF_3, CF_4, O_2, and HeO_2 etchants recited in claims 2-4, 8-10 and 15-17 (see the above discussion for disclosure of mixtures of CHF_3, CF_4, and O_2 etchants).

Without doubt, the present specification discloses dry etching with a single gas (see paragraphs [0014] and [0031], pp. 4 and 7-8 as originally filed, respectively). Consequently, those skilled in the art would readily understand that the above-identified application discloses and conveys dry etching the organic antireflection coating 14, the silicon nitride (polish stop) film 13, the pad oxidation layer 12 and the semiconductor substrate 11 using one or more of the gases recited in claims 2-4, 8-10 and 15-17.

To the extent that the disclosures of certain gases in paragraphs [0014] and [0031] of the present specification are considered erroneous, the Amendment filed September 16, 2005 corrects readily apparent errors in the disclosure. Correction of an error is not new matter if one skilled in the art would appreciate not only the existence of an error, but what the error is. *Koito Mfg. Co. v. Turn-Key-Tech, LLC*, 381 F.3d 1142; 72 U.S.P.Q.2D 1190 (Fed. Cir. 2004), citing *In re Oda*, 58 C.C.P.A. 1353, 443 F.2d 1200, 1206 (C.C.P.A. 1971). As discussed above, one skilled in the art would readily ascertain that any disclosure limiting dry etching the organic antireflection coating 14, the silicon nitride (polish stop) film 13, the pad oxidation layer 12 and the semiconductor substrate 11 to a single gas is erroneous in certain cases (e.g., O_2 and Ar). Thus, to the extent paragraphs [0014] and [0031] of the disclosure are considered to contain one or more errors, correction of such errors is not new matter.

Furthermore, as discussed above, the specification as originally filed inherently discloses dry etching with a mixture of the more than one of the gases. Because the amended subject matter is inherently contained in the originally-filed application, it does not constitute new matter. *Koito Mfg. Co. v. Turn-Key-Tech*, citing *Schering Corp. v. Amgen Inc.*, 222 F.3d 1347, 1352 (Fed. Cir. 2000). Thus, no new matter was introduced by the Amendment filed September 16, 2005.

Therefore, this ground of rejection should be withdrawn.

The Rejection of Claims 1-4, 6, 8-10, 12-17 and 19-20 under 35 U.S.C. § 102(e)

The rejection under 35 U.S.C. § 102(e) of Claims 1-4, 6, 8-10, 12-17 and 19-20 as being unpatentable over Moore et al. (US 6,884,725) is respectfully traversed.

Moore et al. discloses a method of forming a trench in a semiconductor device, where the method includes forming a polish stop layer on a semiconductor substrate, etching the polish stop layer and etching the semiconductor substrate to a predetermined depth to form a trench, and forming an insulation layer that fills the trench. However, Moore et al. fails to disclose or suggest the steps of forming an organic anti-reflection coating on the polish stop layer or etching the semiconductor substrate to a predetermined depth to form a trench that has sloped sidewalls, as recited in Claim 1 above.

Moore et al. disclose in FIG. 10 a wafer fragment 10a that comprises a substrate 12, a pad oxide layer 14, and an etch-stop layer 16 overlying oxide layer 14. Etch-stop layer 16a can comprise, for example, silicon nitride. Nitride-containing etch-stop layer 16 has been subjected to a facet etch to reduce a sharpness of corners 22 (FIG. 5). Specifically, etch-stop layer 16a (FIG. 10) comprises a facet 50 in place of corner 22 (FIG. 5), and has effectively replaced corner 22 with a pair of corners 52 and 54. Each of corners 52 and 54 comprises an angle greater than the about 90° angle of corner 22 (FIG. 5). Accordingly, the facet-etching of the exemplary first embodiment processing has effectively removed a portion of upper corner 22 (FIG. 5) to reduce

a sharpness of the corner angle from a first degree (here about 90°) to a second degree (which here comprises an angle of greater than 90°). (Col. 4, ll. 20-46 of Moore et al.)

FIG. 12 of Moore et al. illustrates a semiconductor wafer fragment 10c at a processing step similar to the prior art processing step of FIG. 1. A difference between semiconductor wafer fragment 10c of FIG. 12 and wafer fragment 10 of FIG. 1 is that wafer fragment 10c comprises an etch-stop layer 16c having two distinct portions, whereas wafer fragment 10 comprises an etch-stop layer 16 containing only one portion. The two portions of etch-stop layer 16c are an upper portion 70 and a lower portion 72. Preferably, upper portion 70 has a faster etch rate when exposed to subsequent etching conditions than does lower portion 72. (Col. 6, ll. 24-33 of Moore et al.)

For example, in applications wherein etch-stop layer 16c comprises nitride, upper portion 70 can comprise $Si_xN_yO_z$, wherein x, y and z are greater than zero, and lower portion 72 can consist essentially of SiN. Upper portion 70 will then etch faster relative to lower portion 72 under subsequent etching conditions comprising exposing nitride-containing layer 16c to hydrofluoric acid. (Col. 6, ll. 33-39 of Moore et al.) Thus, regardless of whether Moore et al. recite any anti-reflective properties for upper portion 70, Moore et al. do not anticipate the present Claim 1, which recites an organic antireflection coating.

Furthermore, each opening 20 in substrate 12 shown in FIGS. 3-5, 10-11 and 13-14 of Moore et al. has straight sidewalls. Moore et al. do not affirmatively disclose any openings 20 in substrate 12 that have sloped sidewalls, either in the Figures or in the specification. Thus, Moore et al. do not anticipate the present Claim 1, which recites a trench having sloped sidewalls.

Consequently, this ground of rejection is unsustainable, and should be withdrawn.

All of the remaining claims depend, directly or indirectly, on Claim 1. Therefore the rejections under 35 U.S.C. § 102(e) of Claims 1-4, 6, 8-10, 12-17, and 19-20 should be withdrawn.

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The Rejections of Claims 5, 11 and 18 under 35 U.S.C. § 103(a)

The rejections under 35 U.S.C. § 103(a) of Claims 5, 11 and 18 as being unpatentable over Moore et al. (US 6,884,725) have been addressed by amendment.

As discussed herein, Moore et al. fails to disclose the steps of forming an organic anti-reflection coating or etching the polish stop layer and the semiconductor substrate to form a trench that has sloped sidewalls, as recited in Claim 1. Furthermore, Moore et al. do not appear to suggest either of these steps. As a result, Claim 1 is fully patentable over Moore et al.

Claims 5, 11 and 18 depend indirectly on Claim 1. Therefore the rejections under 35 U.S.C. § 103(a) of Claims 5, 11 and 18 should be withdrawn.

Conclusions

In view of the above amendments and remarks, all bases for objection and rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,

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